Measuring What Matters: Designing Classroom-Based Assessments that Support Three-Dimensional Science Teaching and Learning

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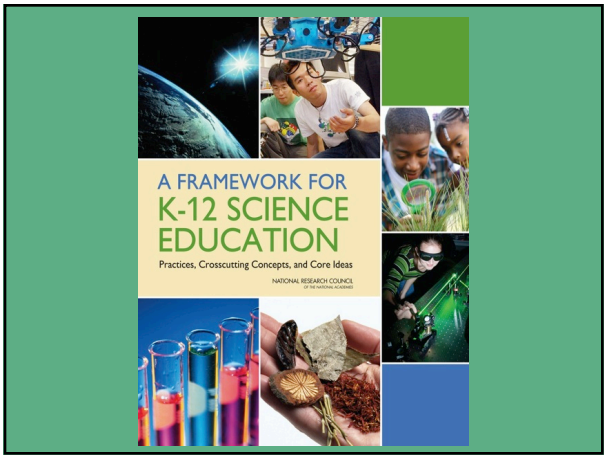
Key Questions for Montana's Educators

1. What are the conceptions that most people you know, including policy makers, educators, parents, and the public, have about
   - **What it means to know and learn science**?
   - **The teaching of science**?
   - **The assessment of science learning**?
2. To what extent do those conceptions **help or hinder** the process of **designing and implementing high quality instruction** that includes assessments of "three-dimensional" science learning as part of normal educational practice?
3. What would it take for the state of Montana to **design and implement a coherent and balanced science assessment system** tied to contemporary science standards? What are the opportunities as well as the barriers?

Foci of Today's Discussion

- Defining Competence to Achieve Coherence in Science Education
- NGSS and Instructionally Supportive Assessment
- From NGSS Performance Expectations to Assessments Designed for Classroom Use

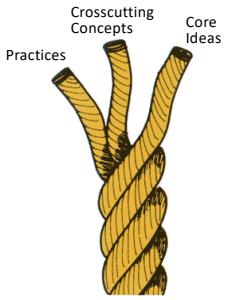


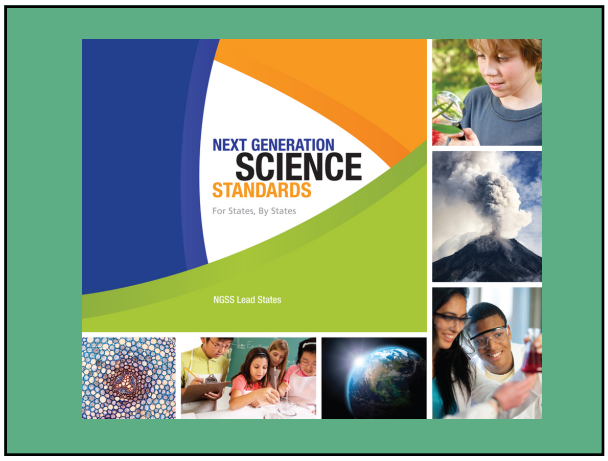
New Definition of Competence

- The NRC Science Framework has proposed descriptions of student competence as being the intersection of knowledge involving:
  - **important disciplinary practices**
  - **disciplinary core ideas,**
  - **and crosscutting concepts** with
  - **performance expectations** representing the intersection of the three.
- Competence is something that develops over time & increases in sophistication & power as the product of coherent curriculum, instruction & assessment

NRC Framework's Goals for Teaching & Learning

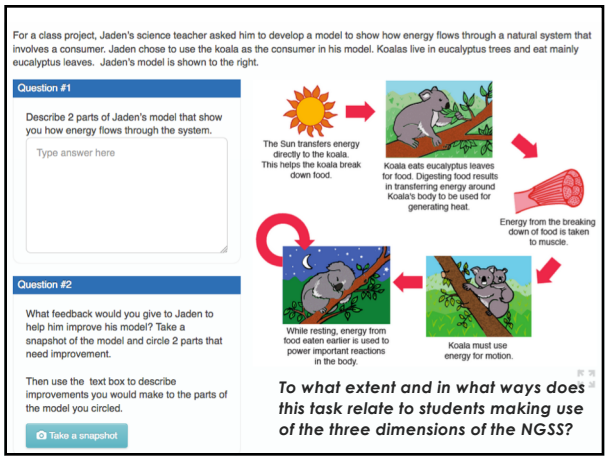
- Coherent investigations of core ideas across multiple years of schooling
- More seamless blending of practices with core ideas
- Performance expectations that require reasoning with core disciplinary ideas
  - explain, justify, predict, model, describe, prove, solve, illustrate, argue, etc.





SCIENCE EDUCATION WILL INVOLVE LESS:	SCIENCE EDUCATION WILL INVOLVE MORE:
Rote memorization of facts and terminology	Facts and terminology learned as needed while developing explanations and designing solutions supported by evidence-based arguments and reasoning.
Learning of ideas disconnected from questions about phenomena	Systems thinking and modeling to explain phenomena and to give a context for the ideas to be learned
Teachers providing information to the whole class	Students conducting investigations, solving problems, and engaging in discussions with teachers' guidance
Teachers posing questions with only one right answer	Students discussing open-ended questions that focus on the strength of the evidence used to generate claims

Source: National Research Council. (2015). Guide to Implementing the Next Generation Science Standards (pp. 8-9). Washington, DC: National Academies Press. https://www.nap.edu/catalog/18802/guide-to-implementing-the-next-generation-science-standards



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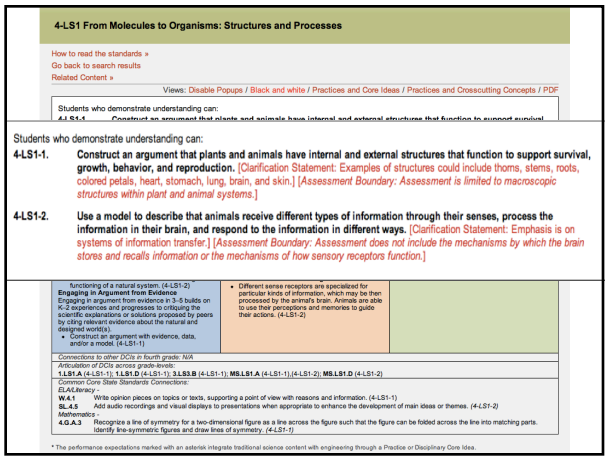
Two Major Features of the NGSS

- Built on the idea of Progressions in the Sophistication of Student Understanding - as previously articulated in the NRC Framework
- Include a new "Architecture" with a focus on Performance Expectations that draw from the intersections of disciplinary core ideas, science and engineering practices, and cross-cutting concepts



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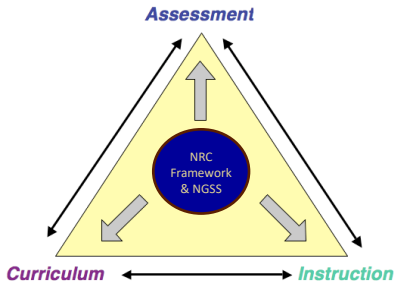
Framework & NGSS as the Basis for Aligning C-I-A



Assessment Designed to Support Instruction

- To develop the skills and dispositions to use scientific and engineering practices to further their learning and to solve problems, students need to experience instruction in which they
  - use multiple practices in developing a particular core idea and
  - apply each practice in the context of multiple core ideas.
- Effective use of the practices will require that they be used in concert with one another, such as in supporting explanation with an argument or using mathematics to analyze data
- Assessments will be critical supports for this instruction.
- The proper design and use of such assessments poses a major conceptual and operational challenge.

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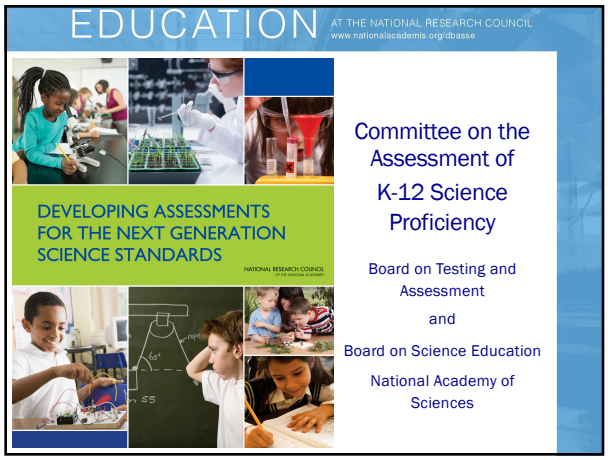


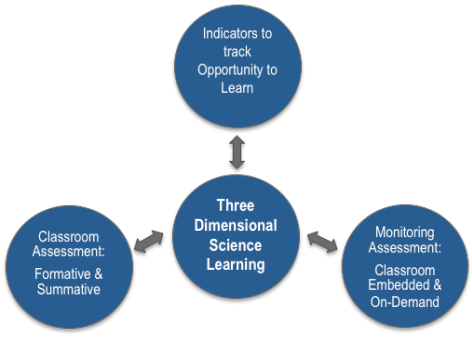
Report's Main Messages

1. Assessment tasks should allow students to engage in science practices in the context of disciplinary core ideas and crosscutting concepts. This poses a significant design challenge.
   - Multi-component tasks that make use of a variety of response formats will be best suited for this.
   - Selected-response questions, short and extended constructed response questions, and performance tasks can all be used, but should be carefully designed to ensure that they measure the intended construct and support the intended inference.
2. Students will need multiple and varied assessment opportunities to demonstrate their proficiencies with the NGSS performance expectations.

Third Critical Message: Build a Coherent System of Assessments

3. A system of assessments will be required and should include classroom assessment, monitoring (large-scale) assessments, and indicators of opportunity to learn.
   - **Classroom assessment should be an integral part of instruction and should reinforce the type of science learning envisioned in the framework and NGSS.**
   - Monitoring (large-scale) assessments will need to include an on-demand component and a component based in the classroom (classroom-embedded) in order to fully cover the breadth and depth of the NGSS performance expectations.
   - Indicators of opportunity to learn should document that students have the opportunity to learn science in the way called for in the framework and NGSS and that schools have appropriate resources.

Assessment System Components



Report's Main Messages (cont.)

4. Implementation should be gradual, systematic, and carefully prioritized, **beginning with classroom assessment** and moving to monitoring assessment.

5. Professional development, adequate support for teachers, and innovative applications of technology will be critical.

Give Precedence to Classroom Assessment

Why Focus on Assessment in the Classroom?

- Instruction that is aligned with the framework and NGSS will naturally provide many opportunities for teachers to observe and record evidence of students' learning.
- Student activities that reflect such learning include
  - developing and refining models;
  - generating, discussing, and analyzing data;
  - engaging in both spoken and written explanations and argumentation;
  - reflecting on their own understanding.
- Such opportunities are the basis for the deployment of assessments of three-dimensional science learning.

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How do we *Assess* toward the PEs?

Assess toward Performance Expectations

Next Generation Science Assessment

The challenge:

How can we create assessments that integrate the three dimensions of the NGSS and help teachers assess student's progress toward achieving the performance expectations?

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NGSA Project Goals

Our Project's Overall Goals

Our project is designed to address three main goals:

(1) Construct a comprehensive design model, using an evidence-centered design (ECD) approach, to guide the development of tasks aligned with the NGSS performance expectations

(2) Develop and test technology-based assessment items and rubrics related to these performance expectations,

(3) Develop guidelines and materials for teachers to use these assessments in the classroom for diagnostic and formative purposes.

Project Scope - Focal DCIs for Middle School Science

Physical Science

Matter & Its Interactions
- Structure & properties of matter
- Chemical reactions

Energy
- Definitions of energy
- Conservation of energy and energy transfer

Life Science

From Molecules to Organisms: Structures and Processes
- Organization for matter and energy flow in organisms

Ecosystems: Interactions, Energy, and Dynamics
- Interdependent relationships in ecosystems
- Cycle of matter and energy transfer in ecosystems

Focus on Two Science and Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations and designing solutions
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Considering Multiple Crosscutting Concepts

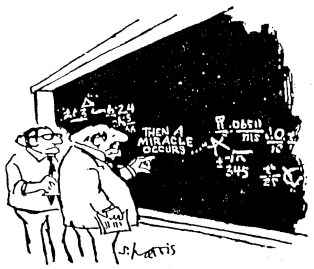
1. **Patterns**
2. **Cause and Effect: Mechanism and Explanation**
3. **Scale, Proportion and Quantity**
4. **Systems and System Models**
5. **Energy and Matter: Flows, Cycles and Conservation**

http://nextgenscienceassessment.org/

Overview of our Evidence-Centered Design Process

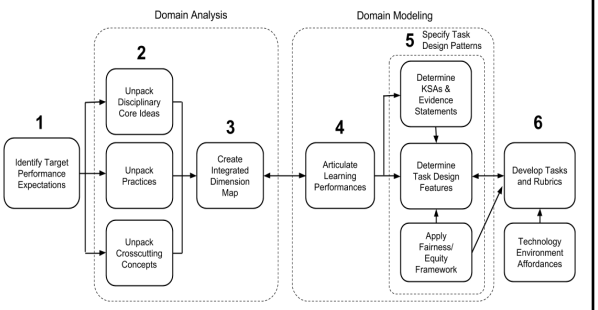
Typical Assessment Design

1. Identify Target Performance Expectations
2. Develop Tasks and Rubrics



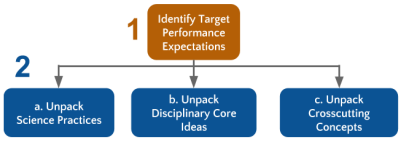
"I think you should be more explicit here in Step Two."

Grand Design Process



Domain Analysis

NGSA Design Process: Domain Analysis



- **Describe each dimension and its components**
- **Identify the requisite knowledge and skills**
- **Specify features of a high level of performance**
- **Identify intersections across the dimensions**

Why Unpack??

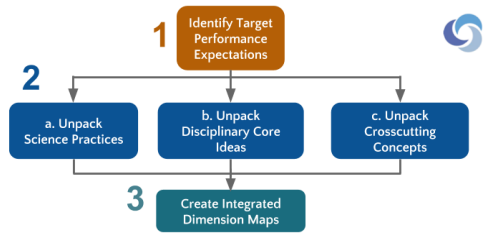
The unpacking process enables one to:

- Understand what each dimension really means
- Identify the essential components of each dimension
- Pinpoint the knowledge and capabilities students need to use in order to use and apply a given dimension
- Describe levels of performance for the dimensions at the grade level you are interested in. Always – unpack with the student in mind.

This process is of high value because it:

- Promotes consistency in your use of dimensions
- Sustains the essential aspects of each dimension
- Sets the stage for constructing learning performances

NGSA Design Approach: Domain Analysis

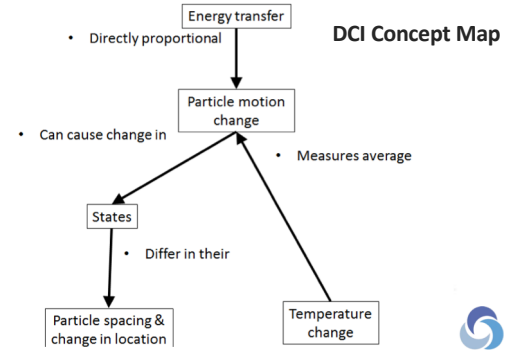


We draw from the unpacking to lay out the conceptual "terrain" of the PE:

- Lay out the essential Disciplinary Relationships
- Link the Disciplinary Relationships to the crosscutting concepts and practices

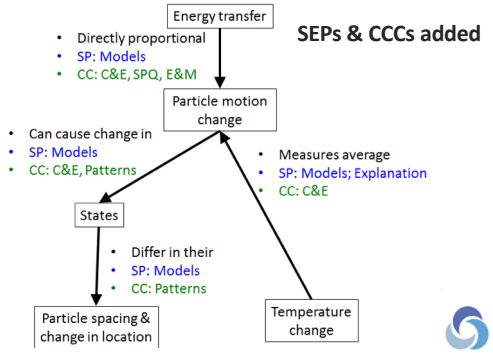
MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

DCI Concept Map



MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

SEPs & CCCs added



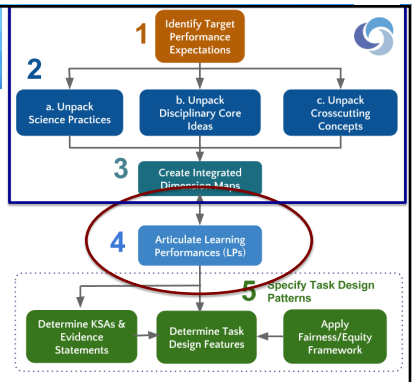
Domain Modeling

NGSA Design Process

Intentional and Explicit

Phase 1: *Domain Analysis*

Phase 2: *Domain Modeling*



We define 3-D building blocks called LEARNING PERFORMANCES

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

- Each PE integrates the 3 dimensions and represents end-of-grade band goals
- Teachers need ways to assess 3-D proficiency and support students' progress toward PEs

We develop what we call: **Learning Performances**

Learning Performances

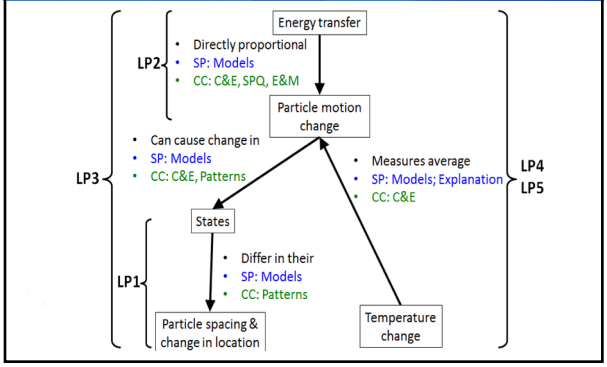
What is a Learning Performance?

- Knowledge-in-use statement that integrates *aspects* of a disciplinary core idea, practice, and crosscutting concept encompassed in a performance expectation
- Smaller in scope and partially represents a performance expectation
- A related set of learning performances function together to describe the performances needed or "what it takes" to achieve a performance expectation(s)

Why use Learning Performances?

- Ideal for classroom-based assessment – answers the question: *How will I know if students are making progress toward this large performance expectation?*
- Specifies "knowledge-in-use" – using "know" or "understand" is too vague
- Emphasizes understanding as embedded in practice and not as memorizing static facts or executing "naked" procedures

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.



Learning performances build towards a PE

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

- **LP E-01:** Students evaluate a model that uses a particle view of matter to explain how states of matter are similar to and/or different from each other
- **LP E-02:** Students develop a model that explains how particle motion changes when thermal energy is transferred to or from a substance without changing state.
- **LP E-03**: Students develop a model to explain the change in the state of a substance caused by transferring thermal energy to or from a sample.

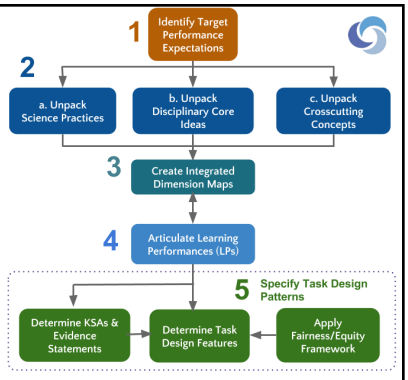
NGSA Design Process

Intentional and Explicit

Phase 1: *Domain Analysis*

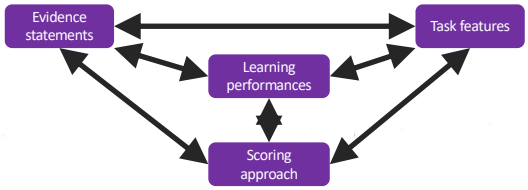
Phase 2: *Domain Modeling*

Phase 3: *Create tasks and rubrics*



Assessment as argument from evidence

- What do we want students to know and be able to do? (Learning performances)
- What evidence will students need to provide to demonstrate proficiency?
- What task features will elicit the desired evidence?
- What scoring approach will help us interpret the evidence?

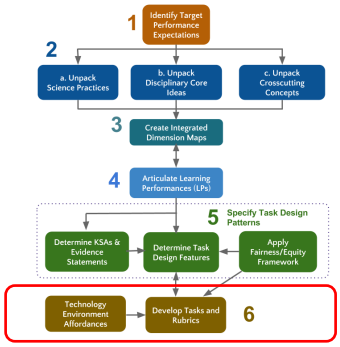


Specify Task Design Pattern for LP

Construct the Assessment Argument
Claim (the Learning Performance)
Focal Knowledge, Skills, & Abilities ("FKSAs")
Additional Knowledge, Skills, & Abilities
Evidence Required to Demonstrate Proficiency
Characteristic Task Features – present in each task
Variable Task Features – present in some tasks

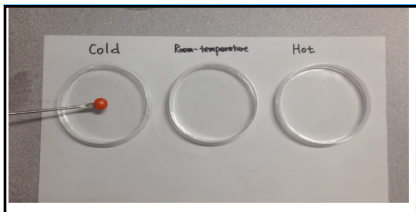
Developing and Evaluating Tasks

Developing Tasks & Rubrics



Tasks built to align to LPs

- Claims in the Learning Performances, and their associated evidence statements, are used to identify task characteristics
- One LP will have multiple tasks that can be designed to vary in difficulty
- Exemplar responses written for each task, checked against the LP/Task evidence statement
- Multidimensional rubrics are specified for scoring
- Student data are collected to refine task design and scoring rubrics

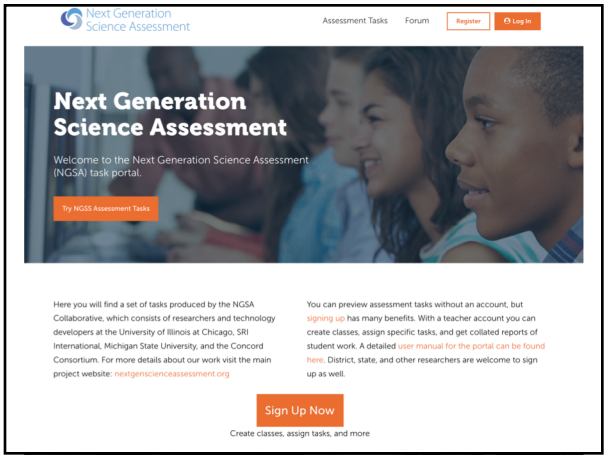


Shawn had 3 dishes of water at room temperature. She cooled one dish, causing thermal energy to transfer from that dish to the surroundings. She kept the middle dish at room temperature. She transferred thermal energy into the third dish by heating it. Then, Shawn dropped a red-coated chocolate candy into each dish. Watch what happened using the video.

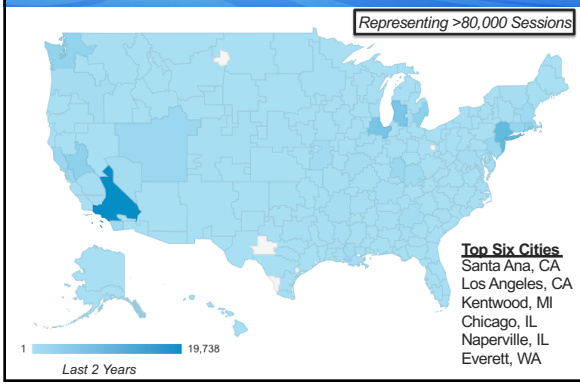
Variable Task Features

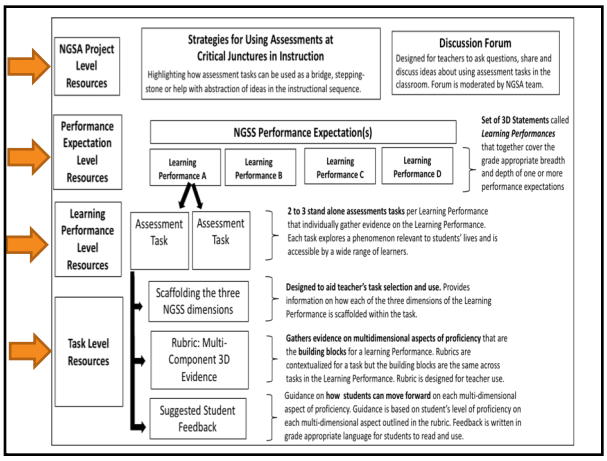
- Use of words, graphics, and/or video to present context – **text & video**
- State of matter of substances – **liquid**
- Language demands – **reduced**
- Level of scaffolding to construct model – **yes**

Supporting Classroom Practice



NGSA Online Portal Data Usage





Whither Goest Montana?

Revised Questions for Montana's Educators

1. **What can be done to positively influence the conceptions** that most people you know, including policy makers, educators, parents, and the public, have about
   - What it means to know and learn science?
   - The teaching of science?
   - The assessment of science learning?
2. **How can you marshal such a conceptual change process to assist** in the design and implementation of high quality instruction that includes assessments of "three-dimensional" science learning as part of normal educational practice?
3. **How can you help your state** design and implement a coherent and balanced science assessment system tied to your science standards? What are the opportunities and **how can you help remove some of the barriers?**

You can't always get what you want
You can't always get what you want
You can't always get what you want
But if you try sometimes you just might find
you get what you need!!!!

Thoughts, Questions & Comments